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ABSTRACT

A computer system, IconiCase, is currently being developed to assist users in the task of classifying and memorizing medical cases. The system uses assemblies of icons, called Concept Graphics (CG), as pointers to medical cases, leading to a form of electronic document delivery in which information is accessed at various levels, with a gradual transition between levels. Icons are designed to be interpreted without the help of textual explanations; however, when a new icon is introduced, its textual interpretation is automatically provided and its correspondence to the text of the case is highlighted. In the icon editor, new icons can be made by screen captures of basic shapes created with a standard painting or drawing program. It is argued that even short gaps in the way information is presented to users lead to cognitive difficulties that could be prevented by better human/machine interfaces; CG, as mnemonic devices, provide meaning that is remembered by the viewer on the basis of cues offered by the icons. In addition, the active role given to users in organizing their access to the information leads to more effective information retrieval. Problems of using iconic compositions include: difficulty in interpretation, unclear meaning for a juxtaposition of several icons, icons' excessive use of valuable screen space, and cumbersome manipulation. (Contains 21 references.) (AEF)

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IconiCase: A visual system for rapid case review

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Abstract: A computer system is proposed to assist humans in the task of classifying and memorizing medical cases with the help of assemblies of icons, called Concept Graphics (CG). This leads to a form of Electronic Document Delivery in which information is accessed at various levels of details and the transitions between the levels is gradual. Also it is argued that rapid review of large sets of documents for content and differential analysis is a valuable activity that can be effectively supported by electronic systems.

Since Antiquity Medical knowledge has essentially been case-based, despite the relatively recent growth of knowledge that links biological facts and processes into increasingly complex and accurate causal models. Medical students and professionals still use reference manuals, such as The Merck Manual (Merck, 1992) describing large numbers of distinct pathologies. Apart from very specific and narrowly circumscribed domains, applications of Expert Systems so far have not provided a totally satisfactory answer to the problem of automating or assisting diagnostic reasoning. Physicians remain reluctant to adopt computer decisions made on a narrow information base. Consequently the more recent systems are oriented toward combining intelligently assisted information retrieval and decision making (Kushniruk, 1994). Apart from providing a richer context for decision making, this fulfills the additional role of helping humans in forming useful categorizations and memorizing large numbers of medical pathologies (Hirtle, 1986).

In this paper we describe a computer system, currently under development and called IconiCase, to assist humans in the task of classifying and memorizing medical cases. More specifically, the system exploits assemblies of icons, called Concept Graphics (CG) as pointers to medical cases (Preiss 1992). This leads to a form of Electronic Document Delivery in which information is accessed at various levels of details and the transitions between the levels is more gradual than in outline systems such as Microsoft's More (Symantec 1992) or window oriented hypertext systems such as NoteCards (Halaz, 1987) or Intermedia (Yankelevitch 1985). In (Kaltenbach, 1988-1991) various ways of providing smooth transitions in information delivery are explored. It is argued that even short gaps in the way information is presented to humans, such as when details are added in separate windows to offer a complement information to a particular point in a mathematical proof, lead to cognitive difficulties, that could be prevented by better human/machine interfaces. Another important aspect of the system, is the active role given to users in organizing their access to the information.

Access to information by the intermediary of icons has received much attention since the beginning of computer graphic interfaces. However in most of the applications proposed so far the meaning and use of icons is quite restricted. Desktop icons for operating systems interfaces have a very simple meaning that allows little variations, if at all. There are very few systems that place meaning in the composition of icons. Systems for visual programming (TGS, 1993) only provide a more readable syntax for programs; the iconic compositions do not have to be interpreted as sets. Iconic compositions, used to formulate queries on a database (Erradi, 1988),(Chang, 1990) form the closest work to what we are proposing; however only a partial use of icons is made to access the documents. The retrieved documents themselves are not assessed with the help of iconic compositions. In addition in the early applications the need to translate queries in a database language, such as SQL, placed severe constraints on the kind of information that can be conveyed through iconic compositions. In this work we attempt to relax the constraints on the kind of information that can be encapsulated into iconic compositions and seek computer solutions to attenuate if not remove completely the ensuing cognitive

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difficulties associated with the use of icons. In the first part of this paper we define Concept Graphics and propose them as useful intermediaries between text and human mental representations.

Concept Graphics

In the following the detailed descriptions of medical pathologies that form a corpus of documents are called cases. Cases are obtained in the form of texts that can be very detailed, such as entries in The Merck Manual. A case has a unique textual identifier plus textual and iconic indexing terms. In addition it is represented by a composition of elementary icons, called a Concept Graphics (CG), that captures the main characteristics of the case, such as symptoms, treatments, factors such as age, habits, etc. Thus the CG components need not be homogeneous. The choice of these characteristics may reflect the biases of a particular expert, or general user of the system. An example of a CG corresponding to the case "acute pancreatitis" is given in Figure 1 . Note that the use of color make the CGs more easily identifiable..

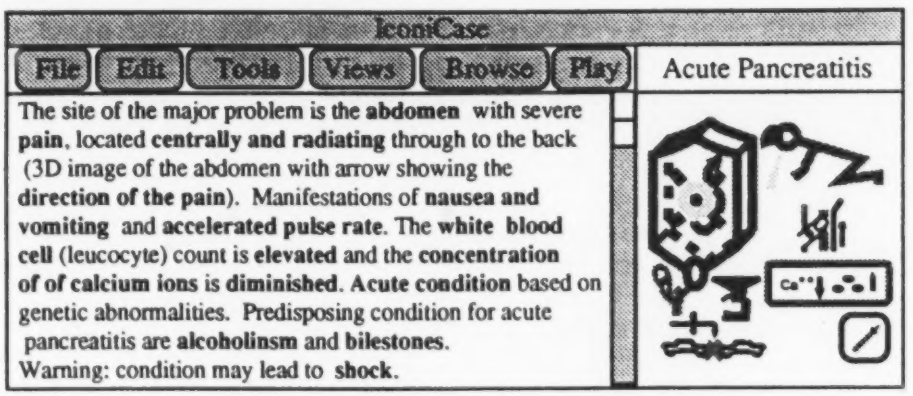
IconiCase
File
Edit
Tools
Views
Browse
Play
Acute Pancreatitis
The site of the major problem is the abdomen with severe pain, located centrally and radiating through to the back (3D image of the abdomen with arrow showing the direction of the pain). Manifestations of nausea and vomiting and accelerated pulse rate. The white blood cell (leucocyte) count is elevated and the concentration of of calcium ions is diminished. Acute condition based on genetic abnormalities. Predisposing condition for acute pancreatitis are alcoholinsm and bilestones.
Warning: condition may lead to shock.

Figure 1. A concept graphic and associated short text

For us CG are mnemonic devices, akin to the chimerical compositions used by medieval orators to summarize the main points of the sermon they were going to make. For a CG to be a mnemonic device means that its meaning is not just in the icons themselves, but that it is remembered by the viewer on the basis of cues offered by the icons. It should be noted that the early forms of Mesopotamia writing were assemblies of pictograms representing concrete things or actions (Bottero, 1993). It is only later that syllabic meaning was ascribed to pictograms which, by becoming more abstract, led to the alphabet.

As much as possible icons are designed to be interpreted without the help of textual explanations; e.g. a broken bone, a brain, etc. However there is a limit to the complexity of meaning that can be expressed by icons in the form of familiar concrete objects and abstract icons are a necessity. Our approach to resolving the problem of understanding unfamiliar icons is to link the individual icons as well are icon sequences to text and to introduces the use of new icons in a progressive manner to users. This means that what users are shown in a CG depends on what icons they understand. This also implies that a user model (Sleeman, 1984) be maintained by the system. When a new icon is introduced its textual interpretation is automatically provided and its correspondence to the text of the case is highlighted. In Figure 1, the bolded letter words in the left text field correspond to the icons in the CG on the right. Later we provide additional details on how practically users are made familiar with icons and iconic compositions, as well as the kind of assistance they can have when "reading" iconic compositions.

Discounting for the time being the familiarity/unfamiliarity aspect, the advantage of using CG to access information is the exploitation the human visual processing abilities adapted to deal with objects in multiple dimensions such as space, shape, color, texture . There are several apparent consequences:

- For the same speed of access, more information is obtained by the user than if it had been conveyed in textual form; or conversely the same amount of information is obtained more rapidly. Speed of access is an important factor when dealing with large amounts of documents and traditional access methods through Boolean queries or

natural language processing are too ineffective or cumbersome. Users may simply not have the time available for a long survey. To bring back to mind the content of a large set of documents a sort of rapid browsing called "flying through hypertext" (Lai, Manber, 1991) is needed.
- the many dimensions of iconic compositions and the ability to scan through many cases in a short time result in ways of classifying cases that would not have been obtained through statistical classification methods (Preiss, 1992) because when using these methods often one must know what to look for, either ahead of applying the method or in the interpretation of the results. Machine Learning algorithms (Kodratoff, 1988) and other discovery methods in databases, also fall under that criticism.
- it may be the case that the composition of a CG conveys more meaning than just the sum of its parts.

The limitations of using iconic compositions have been extensively studied and reported in the literature (Iwam, 1991). Experiments comparing the use of abstract icons and text menus have concluded with no advantage for icons (Benbasat, Todd, 1993). Thus,

- interpreting individual icons can be difficult
- it is not clear what meaning to ascribe to a juxtaposition of several icons
- icons use a lot of valuable screen space.
- icons and iconic compositions are cumbersome to manipulate.

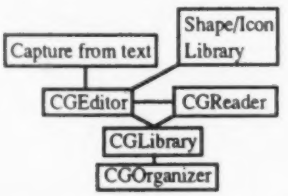

Figure 2. Main modules of Iconicase

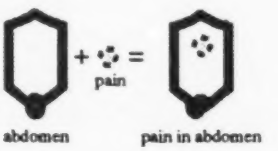

Figure 3. Iconic composition

The system IconiCase is an attempt to capitalize on the advantages of using Concept Graphics, while striving to iron out the difficulties. Figure 2 presents the main modules of the system IconiCase to create and exploit Concept Graphics for surveying and analyzing large sets of cases (i.e. documents). The modules are organized into two main groups corresponding to authoring/editing of CGs and of exploiting CGs in a consultation mode.

Creating Concept Graphics

Capture from Text

Source text, such as entries in The Merck Manual, must be summarized in order to regroup the main features of a case and provide a textual explanation that closely match the corresponding CG. When completed this module will offer a more efficient way of creating the summary text from the original text than by standard cut and paste operations; a user selection of words, group of words and sentences, will be sent to the summary window with only one keyboard operation. Also the system will automatically create links between corresponding parts of the original and summary text, making possible the simultaneous highlighting of corresponding parts of text.

The icon editor

Icons are grouped set of basic shapes that form a sort of collage. This means that basic shapes are not restricted to be rectangles and that they include regions that are transparent. Figure 3 shows the basic shapes "abdomen" and "radiating pain" and the composite icon "pain radiating from center of abdomen". Icons are organized in a multiple inheritance object hierarchy of basic shapes. Each shape or icon has a textual meaning and is indexed by keywords.

New icons can be made by screen captures of basic shapes created with a standard painting or drawing program. There is a tool for defining particular regions of a captured image as transparent or opaque with a color

the user can choose. Regrouping basic shapes, naming and indexing an icon is done in a standard way. It is also possible to create new icons by modifying existing ones retrieved through an icon browser or from existing Concept Graphics.

The Concept Graphic editor

Concept Graphics are assembled manually but we are planning to introduce some automated assistance in selecting the icons and assembling the CGs. For instance the keywords recognized form the text of a case can be automatically translated into icons appearing in the right field of Figure 1. Use of a hierarchical thesaurus (Côté 82) is also considered, to select icons higher in the hierarchy when a recognizable medical term in the text does not have yet a corresponding icon.

The relative placement of icons in a Concept Graphic can be (at least partially) automated by default or production rules. Default placement rules could be statistical. For instance place the new icon at the average position of that icon in already created CGs. Production rules would supersede that default placement to locate semantically related icons at the same relative place in a CG.

Though icons appear with irregular contours, they are included in defining rectangles. This makes it possible to apply a tool we have developed (Kaltenbach, 1991) to compact CGs in as little screen space as possible, while seeking to preserve the relative positions of the composing icons and avoiding the overlap of icons.

It is also in the CG editor that the correspondence between text and icons is established. It has the form of links that enable the simultaneous highlighting (by flashing) of corresponding parts of text and icon groups when a selection in the left text or right image field of Figure 1 is made by the user. A default selection of text or graphic objects is obtained by simply positioning the mouse cursor over the object. Other selection modes for more detailed or coarser selections are also available.

Once a CG is edited it is placed in a CG browser under an appropriate category.

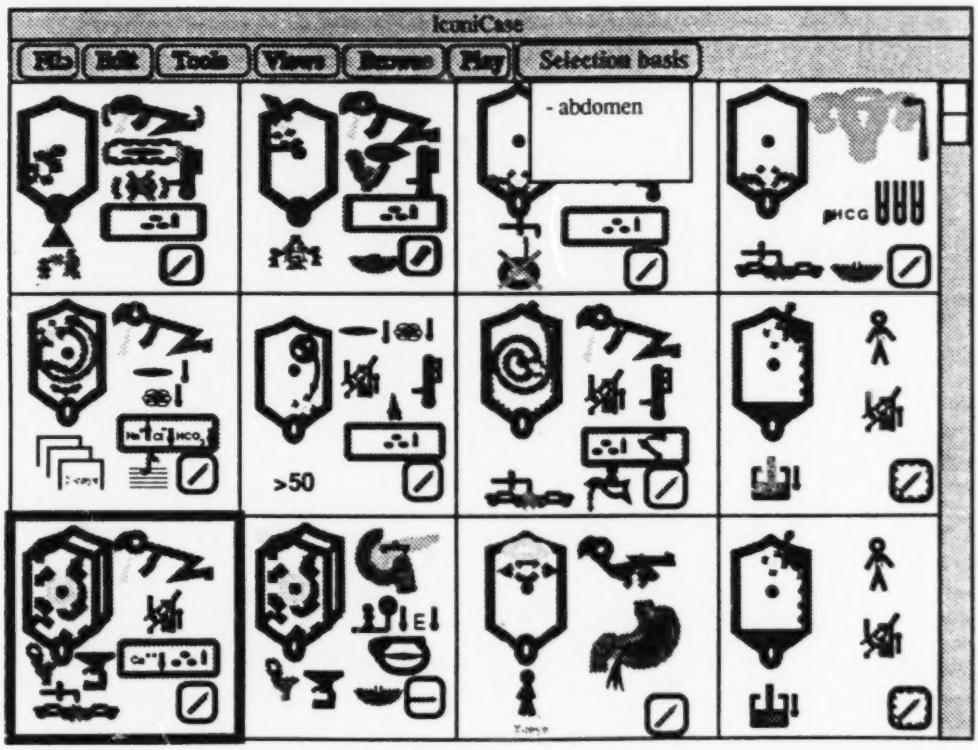

Figure 4. Viewing cases sharing attribute "abdomen" with the case "acute pancreatitis"

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Accessing concept Graphics

In addition to helping users understand a CG, IconiCase provides alternate ways of efficiently scanning through large collections of Concept Graphics. Current implementation includes a CG player, a textual find utility, a browser by semantic categories (e.g. heart diseases, pulmonary diseases,..).

the CG reader is a facility that automatically highlights the keywords, sentences in the left field of Figure 1, together with corresponding icons in the right field. The speed of scanning can be controlled by the reader.

the CG finder is a facility that enables the user to select particular icons or icon components on the right of Figure 1, and obtain the text list or collection of CGs that share the selected features. Figure 4 gives the result of a search when the icon shape "abdomen" is selected. A zoom facility for the CGs in Figure 4 is projected.

the CG player enables users to view CGs (Figure 1) in succession at a speed they can control. The sequences of CGs that can be viewed are defined using the CG sequencer.

the CG sequencer currently permits the definition of CG sequences that correspond to:

- user defined sequences by associating markers on CG seen as in Figure 1 or on clicking on CG as seen in Figure 4.
- sequences corresponding to a semantic category in the CG browser
- finally it is projected to cluster cases on the basis of more semantically related definitions of distance between cases. This may rely only in part on a measure of distance between individual icons.

Any defined sequence can be reordered according to a measure generality for CGs. A detailed definition of this measure would make this paper too long, so we provide only the underlying idea. A partition of the set of icons (and icon components) available in the system is created under the equivalence relation that all the elements of a subset are related if they all index a set of cases that is maximal in the sense that no super set of cases is indexed by all these elements. The number of cases associated with an element of the partition of icons gives a measure of the generality of that icon. Then the generality of a case is obtained as the average generality of its component icons.

The sets of cases as just defined can be ordered by inclusion and thus be accessed as the nodes of a graph. A particular node is seen in our system as a sequence of CGs (Fig. 1) or as a two dimensional display (Fig. 4). The user can traverse links in that graph to refine or expand the generality of the component cases entering in a sequence, while focusing on a set of icons of current interest. In fact there are many ways in which significant navigation can be achieved in that graph and this will be the object of subsequent paper.

Using IconiCase

First we return to the question of how users get to understand individual icons and iconic compositions. At one extreme a user may exploit an already processed collection of cases. By this we mean that the cases have already been summarized and associated with CGs by someone else, acting as author. The user may then choose either to get explanations of complete CGs or to be shown no more than i new icons (i=1,2,...) per CG. By pointing to an individual icon or by selecting a component the user gets the correspondence with the text (left field in Fig. 1) and a more formal definition of the icon in the text field below the CG in Fig.1. Explanations are also available for groups of icons when they are selected by the user.

The other extreme is to let the users be also the authors of the CGs. The interpretation of the icons and groups of icons then does not poses problems; user made associations are in the essence of mnemonic approaches (Yate, 1966). In counterpart the practical value of the system IconiCase then hinges critically on how easy it is to create CGs. We have described some early steps in that direction.

In this paper we are presenting CGs as a prop to memory. For instance it could be used by students in order to assist them in reviewing for exams.

There is another objective to the system IconiCase Note that when viewing a large number of CG, it may not be necessary to understand the individual icons in order to make some inferences. For instance some overall pattern may be detected viewing a large collection of CGs leading to the identification of causal relationships (Knowledge base rules). The scanning of CGs could also be viewed as a complement to automated knowledge discovery approaches in databases. The rapid human scanning of cases obtained by the automated approaches

would further validate or invalidate the newly extracted rule. This is important because usually many rules are discovered by the automated discovery approaches and screening through them to get the really meaningful is a very tedious task.

Future work and conclusion

As an interface for the delivery of large corpora of documents, a system like IconiCase requires many adaptive features and much fine tuning to gain acceptance with a wide variety of users. We have explored some of these dimensions but much remains to be done. We plan to perform experiments with users to study the time needed to learn the meaning of icons and of groups of icons. Also we shall study possible tradeoffs between the depth of details and speed the CGs can be displayed to humans. The criterion of evaluation should how correctly cases are reminisced.

The approach is of course not strictly limited to medical cases. Also it could be considered as an extension of and a complement to case-based reasoning systems (Hammond, 89).

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